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COLORADO BEETLE IN ENGLAND IN RELATION TO ITS SPREAD ON THE CONTINENT

by I. THOMAS

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" The history of various Colorado beetle outbreaks in Europe, and indeed of the outbreaks of any foreign pest in any part of the world, shows only too clearly that successful extermination demands measures of a drastic, and even of an overwhelming nature, put into force without delay." In these words Fryer (1934) introduced his description of the Colorado beetle campaign at Tilbury. The purpose of this paper is to survey very briefly the development of the Colorado beetle campaign since that time, to show what has been achieved by the continued policy of extermination, and what relationship exists between the Colorado beetle situation on the Continent of Europe and that in these Islands.

Our defences against the beetle have been developed until the stage has now been reached when there is little or no deviation from plans made well in advance. Protective measures are the foundation of the campaign, and emergency measures its superstructure.

The protective measures are two-fold—legislation and protective spraying. The Colorado Beetle Orders of 1933 and 1950 make it illegal for a person to keep in his possession a live Colorado beetle or to spray or otherwise treat any crop infested by, or suspected to be infested by, this insect. Other provisions are designed to ensure that the pest shall be dealt with only by qualified officers acting for the Ministry of Agriculture. Under the Importation of Plants Order 1947, restrictions are placed on the importation of potatoes and other agricultural produce from certain countries, with the object of reducing the risk of introducing Colorado beetle and other plant pests and diseases. In considering how far these measures have been effective, it is important to remember that beetles can arrive by all manner of means—on shipping of all kinds, with goods and merchandise of all kinds, and also by being washed up on our shores. So far there is no evidence of beetles having crossed the Channel by direct flight.

The potato is the main host plant of the Colorado beetle, and potatoes from infested areas are always liable to harbour live beetles unless very special measures are taken to prevent infestation : larvae and pupae may also be present with potatoes lifted in infested areas during the summer months. Green vegetables or salad crops with loose foliage are also particularly liable to harbour beetles during the spring and summer months, and experience has shown that of all the agricultural and horticultural produce imported into England and Wales, lettuce harbours by far the greatest number of beetles. It is not clearly understood why this should be so, but it is probable that in many instances lettuce may be the only green crop with abundant foliage available at the time when beetles emerge from hibernation.

When the Importation of Plants Order was introduced in 1939, the Colorado beetle was present only in France, and the active period of the beetle in the main part of the area invaded was from early April until October. At that time, therefore, it was safe to import vegetables liable to harbour beetles at any time from October until the end of March, and this was recognized in the Order. As the beetle has spread southwards on the Continent, so has it emerged earlier

(55312) A*

and earlier in the year until, now that it has reached the shores of the Mediterranean, the period of dormancy is very short indeed. It is possible that in some sheltered spots there is no true hibernation since several beetles have been found in January on lettuce imported from Spain, Italy and the south of France.

Information on the spread of the beetle on the Continent is available from a number of sources (Feytaud, 1936; Ferrière, Défago and Roos, 1944; European Plant Protection Organisation, 1950–52). So far as possible this information has been collated, and the lines of advance of the beetle are shown on the map below (Fig. 1). It will be seen that whereas the spread was at first north-westwards, it is now southwards, and it is interesting to note how mountain ranges—and in particular the Pyrenees—held up the advance of the beetle from 1935 until about 1939. After it had crossed the Pyrenees its advance was rapid, and it has now reached the south coast of Spain. It has also advanced almost as far south as Florence in Italy, and the problem of the possible importation of beetles on early vegetables is becoming yearly more acute. In 1947, the earliest appearance of the beetle in this country with produce imported from the Continent was March 20; in 1948, the earliest imported beetle was found on February 14; in 1949, it was January 15, in 1950, January 7, and in 1951, January 16. This year, 49 single beetles were found between January 1 and April 5: all were on, or associated with, imported produce, and about half were on lettuce from Spain.

Fig. 1. Approximate lines of advance of the Colorado beetle in Europe since 1921.

Attention has already been drawn to the early appearance of the beetle in southern Europe in a report of the Quarantine Working Party of the European Plant Protection Organisation (1951). Paragraph 17 of this report says, *inter alia*, " The hibernation period varies somewhat with locality and climate (for

example, the beetle emerges from the ground a month earlier in the south of France than in the north) and regulations should take account of this fact". The present position in England and Wales may have to be met by legislation which takes account of the spread of the Colorado beetle southwards in Europe.

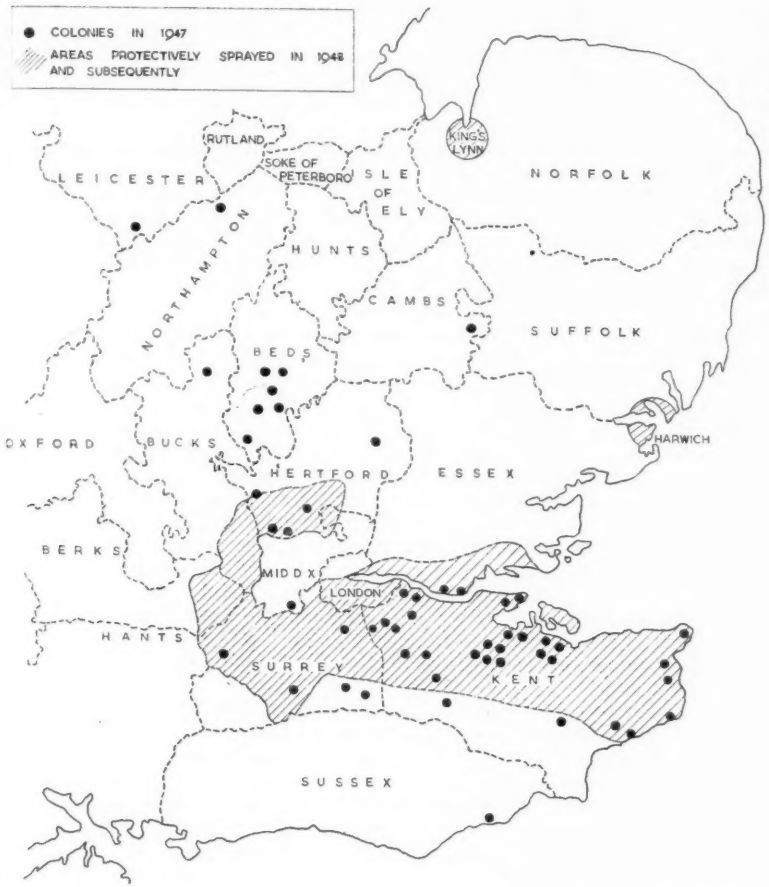

Fig. 2. Distribution of Colorado beetle colonies in England in 1947, and areas protectively sprayed in 1948 and subsequently.

The second line of defence against Colorado beetle is protective spraying. At first it was considered sufficient to spray around infested places both in the year when a colony was found and in the following year. This policy sufficed until the infestation on the Continent built up to large numbers during the war period 1939–45, after which larger numbers of beetles found their way across the Channel. A peak was reached in 1947 when, due to very severe weather, there

was an acute shortage of vegetables in this country ; imports were on a much larger scale than usual and, as an exceptional measure, were continued beyond the date (March 31) specified in the Importation of Plants Order. The districts where most beetles were found were those adjoining routes along which imports came from the Continent, and around the south-east coast of Kent where a number of beetles had been washed ashore. The policy of protective spraying on a fairly wide scale was instituted in 1947. All commercial crops of potatoes in what were considered to be the most vulnerable areas were sprayed early in the season with a DDT insecticide at the rate of 1 lb. technical DDT per acre. The area to be sprayed was greatly extended in 1948 following the large numbers of beetles which had arrived with imported produce in the previous year. The 57 colonies found in 1947 are marked on the map (Fig. 2), and it will be seen how the area protectively sprayed is situated so that it covers that part of the country where most colonies were then found. In subsequent years very few colonies have been found in this area, and of these the majority have been in small gardens or allotments, or on volunteer potatoes. To such an extent has the position improved since 1947 that it has been found possible, at least temporarily, to reduce the area protectively sprayed by omitting that part of it to the north and west of London.

However effective the legislation and protective spraying, some beetles get through to reach unsprayed potato crops, eggs may be laid and the resulting colonies must be immediately eradicated. The methods employed have been fully described by Gimingham and Thomas (1949), and to a very considerable degree they have been successful. In only two instances has the beetle reappeared on sites dealt with the previous year. Both occurred in 1948, after the peak year, when workers were very hard-pressed and the full campaign had not been long established. Also in 1948, six other colonies were found which were probably the result of beetles overwintering in this country, though not on sites previously treated. However, all were subsequently eradicated and no colonies were discovered in 1949. In 1950 there were 29 breeding colonies, but eradication measures were again successful. One colony which was not discovered in that year gave rise to beetles in 1951 when, in all, eight colonies were found, and of the colonies found in 1952, only one was the result of the overwintering of beetles.

That the Continent is the source of nearly all the single beetles found in this country is also demonstrated in the figures given by Thomas and Aitkenhead (1952) of single beetles found in 1951, which are as follows :

Beetles associated with or on imported produce	41
On ships	17
Docksides and beaches	5
Inland on potatoes	0
Inland miscellaneous	8
Odd dead beetles	10
On aircraft	2
	83

As already stated, all 49 of the single beetles found up to April 5 this year were on, or associated with, imported produce. All the evidence therefore goes to show that the source of the great majority of single beetles in this country is the Continent, and that nearly all the beetles found in Britain arrive anew every year.

It is of course to be expected that the number of colonies of beetles found will be far less than the number of single beetles found ; both these are plotted in the graph (Fig. 3), and the expected correlation between them is immediately apparent. The beetles found on ships are not included in these figures, because it is considered that the vigilance of ships' crews, passengers and port authorities is such that all beetles not hidden away in merchandise or produce are killed, and no correlation of colonies with beetles found on ships can be expected.

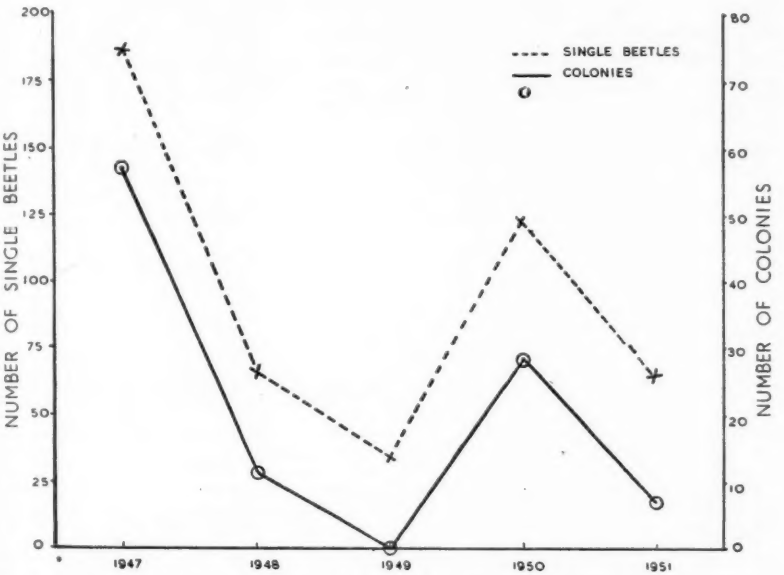

Fig. 3. Relationship between number of single Colorado beetles and beetle colonies found in England and Wales in 1947–51.

Assuming that the campaign against the Colorado beetle in this country is uniformly efficient over a period of years, then the numbers of colonies discovered here will probably continue to reflect the position in Europe. When beetles are abundant on the Continent and conditions are good for multiplying and flight, a considerable number of beetles will, in some way, cross the Channel, and a proportion of them will inevitably escape detection and live to lay eggs and form colonies in this country.

The precise position in all western European countries is regularly reported to the European Plant Protection Organization, and this body is also responsible, in conjunction with the French Ministry of Agriculture, for the intensification of the control measures in that part of France which is nearest the Kent coast. Such measures however, although useful, can only be palliative. The beetle, as with most insects, has such large powers of reproduction that enough beetles to cause severe infestations can build up in one season from small numbers. As propaganda increases, however, and the work of the Organization is developed, so will the control measures on the Continent be more likely to keep the beetle within bounds.

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EUROPEAN PLANT PROTECTION ORGANIZATION

During the last two years the Executive Committee of the European Plant Protection Organization has set up technical Working Parties to consider the status of certain diseases and pests of international importance, and to make recommendations about phytosanitary restrictions and other measures designed to prevent their further spread. Three Reports have been issued and widely circulated by the Organization, whose headquarters is at 14 Rue Cardinal Mercier, Paris.

In the first of these Reports, dated February 1951, particular attention was given to Potato Wart Disease (*Synchytrium endobioticum* (Schilb.) Pers.), Potato Root Eelworm (*Heterodera rostochiensis* Woll.), Colorado Beetle (*Leptinotarsa decemlineata* (Say)) and San José Scale (*Aspidiotus perniciosus* Comst.), and certain recommendations were made with a view to ensuring that future phytosanitary restrictions designed to hinder the further spread of these pests are based on sound scientific reasoning. The second Report, issued in December 1951, included a selected list of about a dozen dangerous non-European diseases and pests, and indicated appropriate measures for minimizing the risk of their introduction into Europe. In its most recent Report, published in July 1952, the Working Party reviewed a number of important fungus, bacterial and virus diseases, as well as three potentially dangerous pests, all of which have secured a footing in Europe, and recommended appropriate phytosanitary measures to prevent their introduction into countries so far free from them.

In promoting study of these questions, the aim of the Organization is to build up an internationally acceptable code of practice in applying phytosanitary regulations, and to help and encourage Governments to ensure that their regulations are based on sound scientific principles, are frequently reviewed, are issued only when really necessary and in a manner that causes as little interference as possible with international trade in plants, and are imposed with due regard to the relative efficiency of the control system in operation in the exporting country.

THE INTERPRETATION OF PROGRESS CURVES FOR POTATO BLIGHT AND OTHER PLANT DISEASES

by E. C. LARGE

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In the course of field work, which began in 1941, on the development of a key for the rapid visual assessment of potato blight on the haulm, it was soon realized that if assessments were expressed as a percentage of the foliage area destroyed, for whole plots or fields, and successive assessments were plotted on a time base, most valuable curves could be obtained depicting the progress of blight on typical crops in different years and in different localities. The work on the key, which was promoted by a Disease Measurement Committee of the British Mycological Society, established a practical method of assessment, and the key itself, first published in the Society's Transactions (B.M.S., 1947), has now stood the test of use by many observers, and on the recommendation of the present N.A.A.S. Disease Assessment Committee it has been adopted for use by the National Agricultural Advisory Service. It has also been adopted by the National Institute of Agricultural Botany.

The key is reproduced below, and the purpose of this contribution is to review some of the many uses of blight progress curves obtained by its aid. A number of actual curves obtained in survey work and trials over the past ten years are given by way of examples, but my object in this article is to discuss the principles and methods involved, and not to give specific results.

KEY FOR THE ASSESSMENT OF POTATO BLIGHT ON THE HAULM

Blight *per cent*	
0·0	Not seen on field.
0·1	Only a few plants affected here and there ; up to 1 or 2 spots in 12 yard radius.
1·0	Up to 10 spots per plant, or general light spotting.
5·0	About 50 spots per plant or up to 1 leaflet in 10 attacked.
25·0	Nearly every leaflet with lesions, plants still retaining normal form : field may smell of blight, but looks green though every plant affected.
50·0	Every plant affected and about half of leaf area destroyed by blight : field looks green flecked with brown.
75·0	About three-quarters of leaf area destroyed by blight : field looks neither predominantly brown or green. In some varieties the youngest leaves escape infection so that green is more conspicuous than in varieties like King Edward, which commonly shows severe shoot infection.
95·0	Only a few leaves left green, but stems green.

In the earlier stages of a blight epidemic, parts of the field sometimes show more advanced decay than the rest, and this is often associated with the primary foci of the disease. Records may then be made as, say, 1 + pf 25, where pf 25 means 25 per cent in the area of the primary foci.

USE FOR REVEALING THE COURSE OF A BLIGHT ATTACK

When percentage assessments are made at frequent intervals and plotted on a time base, it is found that the " characteristic curves " obtained are generally of sigmoid form, or S-shaped, with relatively slow progress at the beginning of the attack (when there are as yet relatively few spores to spread the infection), and also with relatively slow progress at the end of the attack when only a little

of the foliage remains. Large (1945) showed that the curves could often be reduced to straight lines by the probit transformation, and discussed the significance of this in relation to the natural course of infection. In practice, the same transformation is made automatically if the points are plotted on " probability paper "—Chartwell 5572 is suitable—instead of ordinary graph paper. A typical curve plotted in both ways is shown in Fig. 1. It will be noted that the whole course and timing of such an attack may be completely defined by the slope of the progress line and the " half decay " or 50 per cent date.

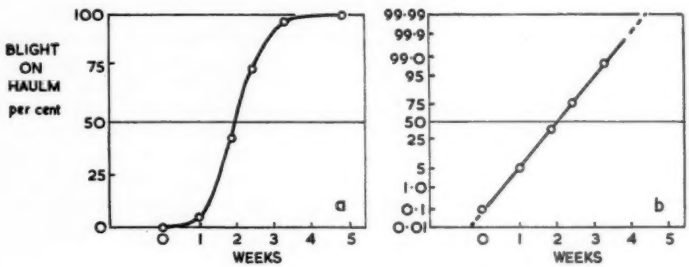

Fig. 1. A typical blight progress curve
(a) plotted on ordinary graph paper, (b) plotted on probability paper.

It is but rarely that a blight attack progresses faster than that indicated in Fig. 1, and the study of a few curves disposes at once of the old belief that blight can destroy the haulm " almost overnight ". The attack usually takes at least a month to run its course, from the appearance of the first few spots on the leaves to the stage at which the haulm is all but dead.

The curves are steep when humidity and temperature conditions favour sporulation of the fungus ; they are more gently inclined and sometimes long-drawn-out when dry weather follows the outbreak and sporulation is checked. In reality the curves are often stepped when weather conditions are intermittently favourable for sporulation, and this may be shown by very careful assessments at intervals of a few days ; in survey work, however, four or five observations over the course of the attack are sufficient to establish the general sweep of the curve. Although there are earlier stages, the starting point of the attack may conveniently be taken as 0·1 per cent by the key, and to obtain this important point fairly accurately it is necessary to inspect the crop at intervals—usually of about 10 days—from the earliest date at which outbreaks are ever likely to occur in the locality.

Fig. 2 shows typical curves for some of the widely differing types of epidemic that may occur on maincrops in England and Wales according to region and season. Curve A shows an exceptionally early course of attack even for the south-west ; B shows a more frequently-occurring course in the south-west in a " blight year ". Curve C shows a rapid course at a time common in the south-west, and unusually early for the east ; D shows a more common course in the east, even in a " blight year " ; such a course of attack is rather late for the south-west but also fairly common there. Curve E shows an attack starting in July but retarded by dry weather until the end of that month and then progressing slowly ; F shows a similar course of attack, but somewhat later, and confused in the end with dying down by mineral deficiency and other

causes, so that the course of blight becomes indeterminate (as shown by the dotted line). Curve G shows a late attack common in the midlands and the north, in which blight causes little loss of crop but endangers the tubers by persisting into October; while H shows a course that is very late indeed, that often occurs in a so-called "no blight year", and that is treacherous in that such "back-end blight", often disregarded, can cause severe infection of the tubers at lifting.

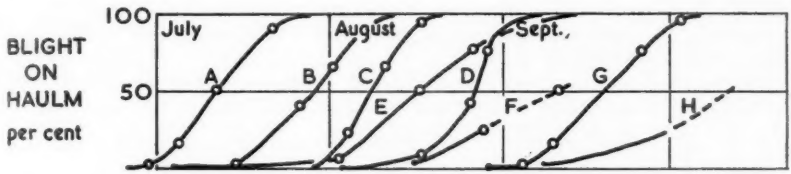

Fig. 2. Some typical blight progress curves for various types of epidemic occurring on maincrops in England and Wales.

A. East Cornwall, 1945. B. Mid-Devon, 1946. C. South of the Wash, 1948.
D. South Devon, 1942. E. Dartmoor, 1945. F. West of the Wash, 1947.
G. South of the Vale of York, 1951. H. Back-end blight in a "no blight year".

USE FOR REGIONAL AND SEASONAL COMPARISONS

It is evident from Fig. 2 that if the progress curves are plotted in groups for regions or for seasons they will provide charts by which regional and seasonal differences can be studied. Such charts for the years 1943–46, for Cornwall, North Devon, East Devon, Yorks and Herts, were drawn up by Beaumont (Moore, 1948) from information provided by members of the Disease Measurement Committee of the British Mycological Society. Since 1950, many very valuable curves have been obtained by Plant Pathologists in the National Agricultural Advisory Service, in connection with a co-operative Potato Blight

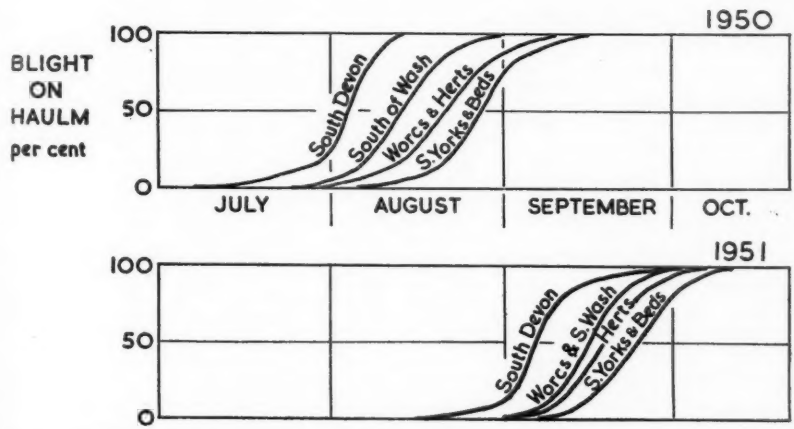

Fig. 3. Typical blight progress curves for six regions in England for 1950 and 1951, demonstrating use of the curves for regional and seasonal comparison.

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Forecasting and Progress Survey, and it is hoped that by continuation of this work it may be possible to extend the indications already obtained and to zone the whole country for relative earliness or lateness of the course of blight. The charts in Fig. 3, for six regions in the years 1950 and 1951, clearly show the value and importance of this work. They show that in 1951 blight in all of the regions was a full month later than in 1950, and they also show that the relative positions of the curves for the several regions were about the same in both years. When read in conjunction with Fig. 4, below, they indicate graphically that in 1950 protective spraying could have given a substantial increase in crop in all of the regions, whereas in 1951 it could have given little increase in any of them.

USE IN ESTIMATING LOSS OF YIELD

With the progressive decay of the haulm due to blight, a point is reached sooner or later at which tuber production stops, and the plants cease to give any further increase in yield. The point of cessation of growth probably varies according to variety and season, but in a provisional way one may say that useful growth is generally over when the blight assessment reaches about 75 per cent by key.

Accepting this figure—and the principle is not altered if one slightly higher or lower is taken—it is possible to project upwards as shown in Fig. 4, from the date of cessation of tuber growth on to a curve showing the mean expected loss of crop when growth is stopped on that date. Such a curve may be obtained from the results of periodic liftings on a number of crops in a number of seasons, and it will vary according to variety. The particular curve shown by way of example in Fig. 4 is derived from the means for 60 crops of Majestic on which fortnightly liftings were made in a co-operative experiment in the years 1940–45 (Gregory and Doncaster, 1948, p. 2). The crops were grown at various centres, well distributed over England and Wales. Some were affected by blight, and may not have received the protective spraying necessary to enable them to give their full increment of yield towards the end of the growing period, but, on the whole, the figures probably give the best general indication of the mean progress of bulking in Majestic in England and Wales that is so far available.

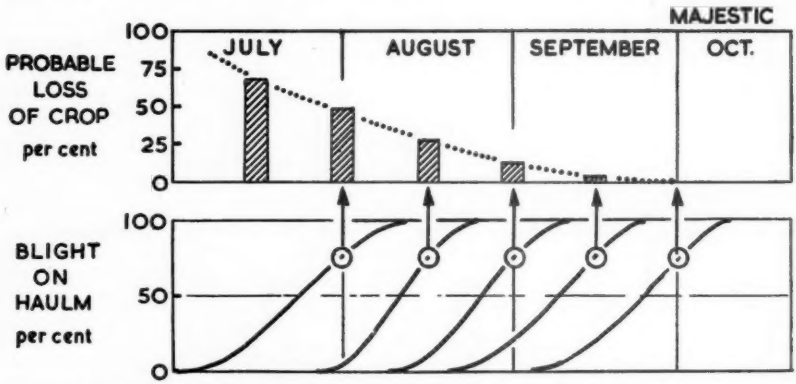

Fig. 4. Estimation of mean probable loss of crop from curves for progress of blight on the haulm. Note that, as explained overleaf, the losses for individual crops due to stoppage of tuber growth on the dates indicated may vary considerably from the mean.

Accepting the curve for probable loss, provisionally and as a basis for discussion, and reading from Fig. 4, one may say that a blight curve in which the 75 per cent point is reached by the end of July, indicates a probable loss of about 50 per cent of the crop ; while one reaching 75 per cent in mid-August indicates about 28 per cent loss. Perhaps the commonest type of curve obtained in " blight years ", reaching 75 per cent by the end of August, indicates a loss of about 13 per cent ; while one not reaching 75 per cent until mid-September, indicates only a very small loss of about 4 per cent. Where the maximum potential crop without blight, as limited by nutritional and other factors, is 10 tons per acre, a loss of 13 per cent, as by stoppage of growth at the end of August, is a loss of 1·3 tons per acre. Where the potential crop is higher, say, 15 tons per acre, stoppage of growth at the same time will probably mean a loss of nearly 2 tons. These are mean figures ; individual crops must be expected to vary considerably about the means, as bulking may be relatively early or relatively late, according to the seasonal distribution of rainfall. A little growth after the 75 per cent point may be balanced by some loss, due to reduction of photosynthetic area, before it.

Although the method of estimating blight losses from curves for blight on the haulm requires further study, and needs much checking against the actual results of spraying trials, it is nevertheless a method which has very great potential value in survey work, and I should like to put on record that the germinative idea is that of my friend and former colleague, Mr. A. Beaumont, who based it on the classical study of the development of the potato plant in relation to spraying made by Paul Murphy (1937), and who put it to good use during our work together on a potato spraying campaign in the south-west (Beaumont and Large, 1944).

EFFECTS OF PROTECTIVE SPRAYING SHOWN BY PROGRESS CURVES

The usual effect of protective spraying, if it is done at or before the 0·1 per cent stage, is to retard the progress of blight on the sprayed haulm so that it runs a course, often almost parallel to that on the unsprayed, but after an interval that may be called " the mean prolongation of growth " (Large, 1945).

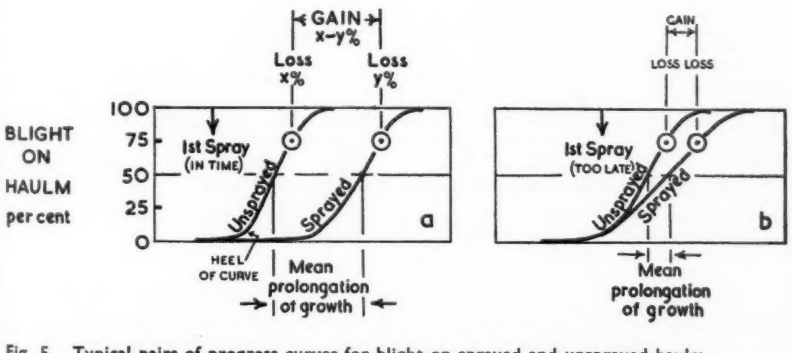

Fig. 5. Typical pairs of progress curves for blight on sprayed and unsprayed haulm. (a) When the first spraying is given at or before the 0·1 per cent stage. (b) When it is given after that stage.

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The gain from spraying is the increase of crop between the 75 per cent dates for the sprayed and the unsprayed, which is but rarely equal to the whole possible gain. This is illustrated by Fig. 5 (a). The displacement of the " heel " of the blight curve (which represents the beginning of the destructive attack), and the parallelism between the curves for the sprayed and unsprayed plant, does not occur if the first spraying is given *after* the 0·1 per cent stage. When that happens, the first spraying is too late to retard mass infection, and it merely alters the slope of the curve by making the course of attack somewhat less rapid. This is illustrated in Fig. 5 (b).

The progress curves for blight in the sprayed and unsprayed plots in a spraying trial reflect the course of reduction in the photosynthetic area of the foliage and weight of the haulm. This may be seen if periodic weighings of haulm and tubers are made in the course of the trial and growth curves are plotted as in Fig. 6. Such growth curves demonstrate very clearly how the gain in yield is obtained by prolongation of the growth of the haulm, and they provide the means of checking the stage at which tuber production ceases, but apart from this they add little to the information provided by the progress curves and the final yield figures for the sprayed and unsprayed plots.

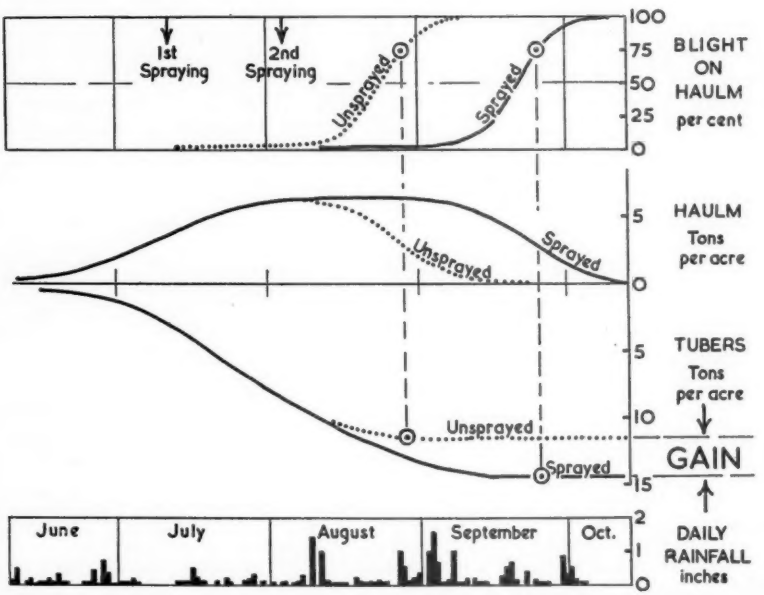

Fig. 6. Blight progress curves in relation to dates of spraying, growth curves for haulm and tubers, and rainfall, in a spraying trial. East Devon, 1946.

It is, however, of great importance to insert the dates of spraying on the blight progress chart, as indicated in Fig. 6, and to chart rainfall or humidity data where these are available. The results of spraying trials are almost meaningless unless the dates of application are given in relation to the course of the blight attack. No matter how many sprayings are applied they cannot

give any great increase in yield if the unsprayed haulm is not destroyed by blight until late in the growing period ; and if some of the sprayings are given much too early the deposits from them may be washed off by rain before they have any protective effect. Moreover, if the first spraying is given too late the whole spraying programme may fail wholly or in part. The bare finding in a particular trial that so-many sprayings gave such-and-such an increase in yield means little ; but where blight progress assessments are given, with times of spraying and yield data, the results of the trial become of the greatest value in indicating the results that may be obtained from spraying wherever similar blight conditions occur.

There is yet another reason for obtaining blight progress curves in spraying trials. Although the main purpose of such trials must always be to determine the effect of spraying on yield, it has to be remembered that yield figures alone will rarely serve to show up small differences in the protective effect of different treatments, or in the susceptibility of different varieties. Even with a very uniform stand of plants and four or five replications, it is difficult to get the significant difference between mean yields down to less than one ton per acre. Blight assessments on the foliage, however, are much more sensitive, and will often show up differences of only one or two days in mean prolongation of growth.

PROGRESS CURVES FOR POTASH DEFICIENCY EFFECTS

The symptoms of potash deficiency are often confused with those of potato blight, and one of the most striking effects of potash deficiency in the field is that, like blight, it causes reduction in yield by shortening the life of the haulm. It may also reduce the photosynthetic efficiency of the foliage, but this is another matter. Fig. 7 shows the growth curves for a crop on potash-deficient soil,

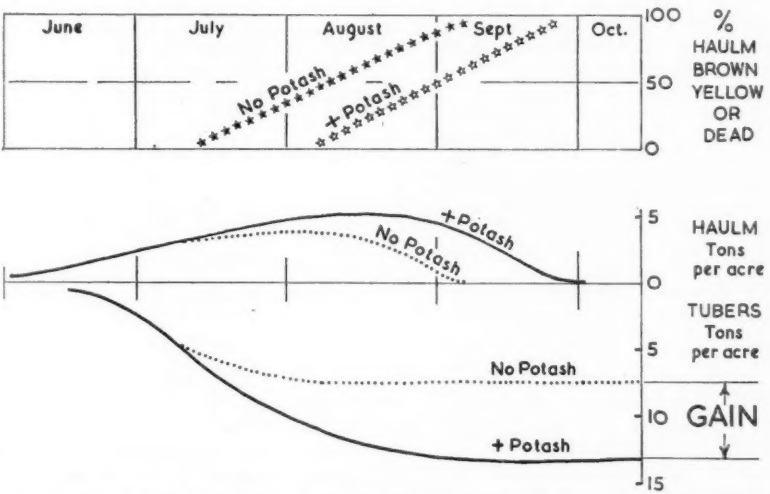

Fig. 7. Growth curves for a potato crop on potash-deficient soil with and without potash in the fertilizer, showing progress curves for haulm decline due to potash deficiency plotted in a similar way to those for decay due to blight. Compare with Fig. 6. South Devon, 1946.

kept free from blight by efficient protective spraying, with and without potash in the fertilizer. If these curves are compared with those in Fig. 6 the similarity in effect of potash deficiency and blight will be apparent. The progress of the dying down of the haulm by potash deficiency, which often renders blight assessment very difficult, may indeed be assessed and recorded in much the same way as that of the decay due to blight ; not, of course, by using the blight key, but by estimating the percentage of the haulm yellowed or dead at each inspection date (Large, Blenkinsop and Le Riche, 1946). The resulting K-deficiency progress curves are indicated in the upper part of Fig. 7. It is often of value to plot such curves, or similar curves for the combined effect of both potash deficiency and blight, where the separate effects of the two are indeterminate.

PROGRESS CURVES IN RELATION TO TUBER INFECTION

During the whole course of the blight attack on the haulm, which, as has been shown, is rarely less than one month and often much longer, the fungus on the foliage is producing spores which may wash or drift down on to the soil. This is indicated by vertical shading in the progress curves shown in Fig. 8. Where the tubers are well covered by soil, they are usually protected from infection, but where the soil cover is deficient, or the soil texture permits infiltration, and there is sufficient rain or soil moisture, tuber infection *may* occur at any time during the course of the attack on the haulm. It may also occur if the potatoes are lifted within ten days or a fortnight of the complete death of the haulm ; and very heavy infection is likely if the lifting is done while the haulm is still green and blight is sporing on it, for then the tubers are exposed and the spores are scattered over them.

Blight progress curves reveal the blight conditions at the end of the growing period, and the likelihood of haulm destruction proving an efficient measure for the prevention of tuber infection, according to the date on which it is done. The use of blight progress curves in haulm destruction trials, has already been shown in a previous contribution to this JOURNAL (Large, 1952).

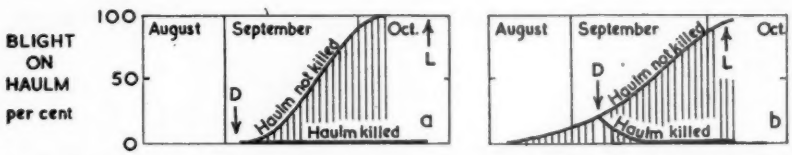

Fig. 8. Haulm destruction (D) and lifting (L) in relation to course of blight on haulm. Vertical shading indicates opportunity for spores from blighted haulm to infect tubers in the soil if they are inadequately covered. (a) Haulm destruction ideally timed for prevention of tuber infection. (b) Haulm destruction preventing infection at lifting, not preventing it before lifting.

When the haulm destruction is timed as in Fig. 8(a), namely, before there is any blight on the haulm, the risk of tuber infection in the soil before lifting is completely guarded against, and so is the risk of infection *at* lifting, as the haulm is dead long before lifting is begun. In the more usual circumstances, however, represented by Fig. 8 (b), where there has been considerable progress of blight on the haulm before the haulm destruction is done, the operation prevents infection *at* lifting, but does not prevent it from occurring *before* lifting, i.e., during the period from the starting of blight on the haulm to the death of the haulm following haulm destruction.

ECONOMIC SIGNIFICANCE OF THE METHODS

When curves for the progress of blight on the haulm have been obtained and related to the yields in carefully conducted spraying trials at only a few well-chosen centres over a number of years, it will be possible to estimate the probable loss of crop that any given type of curve represents, in any part of the country, according to variety and the growing conditions of the season. If then simple eye assessments of the progress of blight on the haulm are made on a number of representative crops in all parts of the country, over a sufficient number of years to cover the wide seasonal variation, a body of records will be built up which will enable advisers to say where protective spraying and/or haulm destruction is needed and where it is not, and to judge the best timing for these operations in each locality, in the light of the conditions of the season and the lessons of the past.

It will become possible to zone the whole country into regions in which routine protective spraying (of certain groups of varieties) is desirable every year ; regions in which routine spraying is not economic, but where occasional spraying may pay in particular meteorological circumstances ; and, finally, regions in which protective spraying gives so little gain, year in and year out, that it is not justified at all. The very different regional zoning for need for haulm destruction will also be determinable. Thus many simple and rapid eye assessments of blight on the haulm, coupled with a few indispensable spraying trials, will suffice to determine the long-term expectation of gain from spraying, region by region, for the country as a whole, and to provide long-needed information of the greatest economic importance concerning spraying policy and the rational deployment of spraying materials, machines and services.

The disease measurement and survey methods outlined in this paper have been developed for potato blight, but, as the example of their application to the estimation of potash-deficiency effects has shown, they are by no means restricted in their applicability to a single disease. With sufficient preliminary field work for the devising of a suitable key, and sufficient study of the course of development of the host plant, they may be applied in the economic epidemiology of a wide range of plant diseases and disorders.

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A VIRUS DISEASE OF COCKSFOOT

by KENNETH M. SMITH

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During the summer of 1950, one or two plants of cocksfoot grass (*Dactylis glomerata* L.) showing some unusual symptoms were received from Dr. I. Storey of the National Agricultural Advisory Service at Leeds (*Plant Pathology*, **1**, 101). Transmission experiments proved that a virus was present and this appears to be the first record of a virus disease of the Gramineae in Western Europe other than the infection of maize with Cucumber Mosaic virus. The name " Cocksfoot Streak " is proposed for the disease.

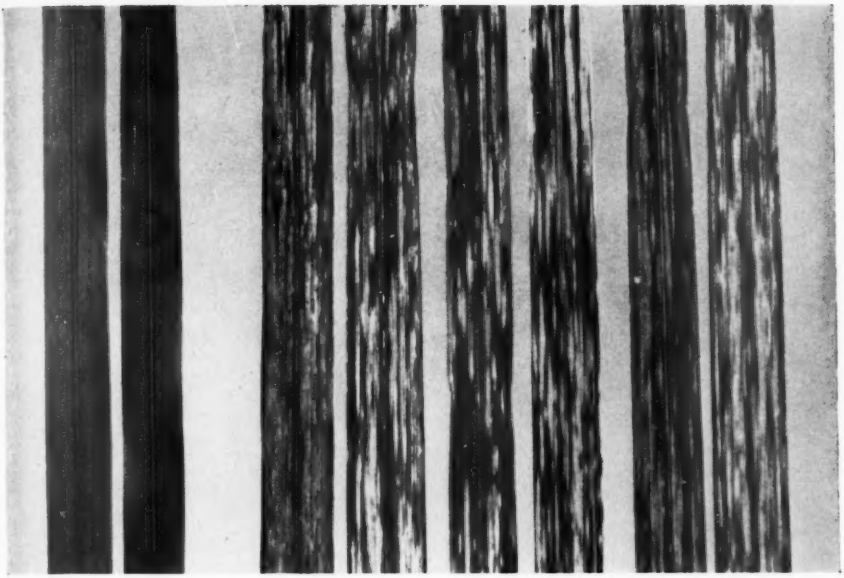
First indications of infection are the appearance of pale streaks on the younger leaves. These increase in intensity and gradually spread throughout the plant until the majority of the leaves are infected. The symptoms vary in severity and diseased plants growing out of doors show a very marked longitudinal streaking of dark and light green or yellow (Plate I, 1) which is similar in appearance to other " streak " diseases of the Gramineae. Infected plants are not markedly dwarfed or stunted, and flowering and seed production seem to be normal (Plate I, 2).

The virus is sap-transmissible, using carborundum, but only with difficulty, and the incubation period in the plant is very variable. Under good growing conditions in April, symptoms sometimes developed in ten days, but during the winter in the glasshouse the period might be several weeks. The host range seems to be extremely limited and so far all attempts to transmit the virus to any other species except *Dactylis glomerata* have failed. Extensive trials with other grasses, oats, wheat and barley have given negative results. Indeed, for a long time the only successful transmissions were made to plants grown from seed produced by the two original infected plants. However, after many sap-transmission tests to a number of samples of cocksfoot, kindly supplied by the National Institute of Agricultural Botany, one plant of S.143 became infected. Out of the total number of sap-inoculation tests made to young cocksfoot seedlings, eleven successful transmissions were obtained.

Experiments were then made to find an insect vector of the virus, and several species of aphids were used including some of the common grass-feeding species. Successful results were achieved only with *Myzus persicae* Sulz. and *Macrosiphum euphorbiae* Thomas. Out of seven experiments using *M. persicae*, two were positive using a short feed, and one positive with a long feed, on the source of infection. Out of six experiments using *M. euphorbiae*, one test was positive using a short feed and two were positive after a long feed. In all the experiments with both aphids a total of nine plants became infected.

Three experiments each of the three usual tests were carried out on the properties of the virus, i.e., dilution end-point, thermal inactivation and longevity *in vitro*, but owing to the lack of infectivity of the virus all the tests were negative. Of several hundred plants, raised from seed from infected plants to test for seed transmission of the virus, only one developed the disease, and this might have been due to chance aphid infection.

Acknowledgment is due to Miss M. E. Short and Dr. G. S. Verma for their help in carrying out the transmission tests, and to Mr. S. Frey for the photographs.



1. Symptons induced by the streak virus on cocksfoot grass ; healthy leaves (left). × 1½

2. Plant of cocksfoot grass infected with the streak virus (left) ; healthy plant (right). ⅞

PLATE I

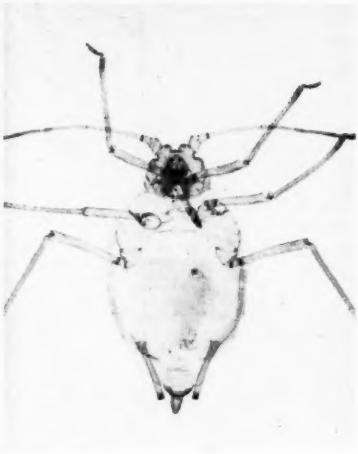
1. *Brachycaudus prunicola* (Kalt.) sensu H.R.L. nec Börner 1952 = *B. semisubterraneus* Börner 1952 (*Prunus domestica*) Apt. v. ♀

2. *Sitobion avenae* (F.) sensu H.R.L. 1939 = *S. granarium* (Kirby) sensu Börner 1952 Apt. v. ♀

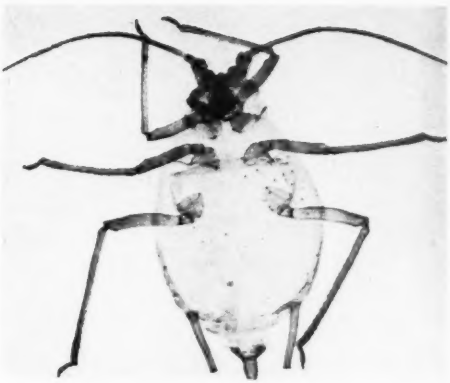
3. *Sappaphis crataegi* (Kalt.) (Carrots) Apt. v. ♀

4. *Nasonovia ribis-nigri* (Mosley) (*Hieracium*) Apt. v. ♀

PLATE II



1. *Myzus persicae* (Sulzer) Apt. v. ♀

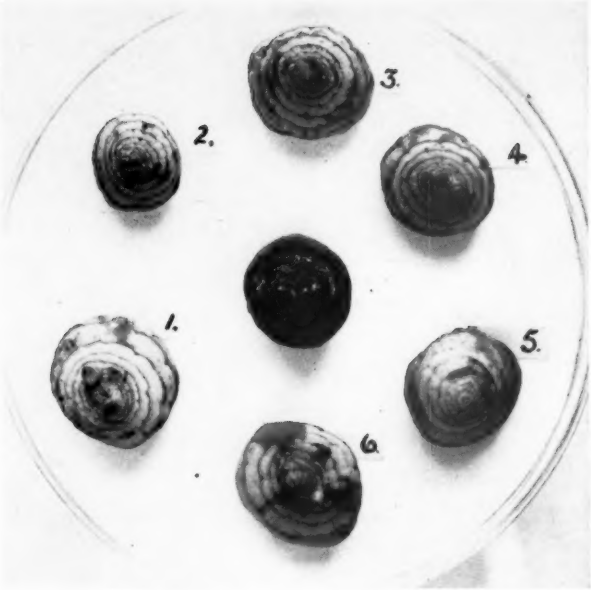


2. *Metopolophium festucae* (Theob.) Apt. v. ♀

3. *Myzus ascalonicus* (Doncaster) Apt. v. ♀

4. *Aulocorthum solani* (Kalt.) Apt. v. ♀

PLATE III



1. A corm with Botrytis Rot (centre) and healthy corms, as arranged in transmission experiments.

2. Botrytis lesion with gravid female mites surrounded by egg clusters. × 20 approx.

PLATE IV

PEDICULOPSIS SP.—A MITE FOUND ON ACIDANTHERA AND GLADIOLUS CORMS

by I. R. HARRISON

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In January 1952, a large number of mites were found on part of a consignment of Acidanthera corms imported from Holland. Investigation showed that the mite was probably a new species, and large numbers of corms were examined for further infestations. The mite was found in corms with Botrytis Rot in three out of six separate consignments inspected. Some time later a single Gladiolus corm showing the Core Rot phase of Botrytis Rot was also found infested with the mite. In both the Acidanthera and Gladiolus corms the Botrytis Rot was found to be caused by *Botrytis gladiolorum* Timmermans.

A systematic description of the mite with details of its life history is in preparation. In appearance the species resembles the Grass and Cereal Mite *Pediculopsis graminum* (Reut.). The life history, however, exhibits some striking differences. Eggs are produced in large numbers. The segments posterior to the fourth pair of legs (the opisthosoma) becomes distended with egg masses and these pass out and surround the body (Plate IV, 2). The size of the gravid female increases until it is no longer able to move. It is this reproduction stage which is readily seen ; the young mites are more difficult to detect as they all move very quickly and are small in size. The non-gravid female is 0·3 mm. in length, and the male 0·2 mm. approximately. The eggs hatch after about two days and the small six-legged larvae emerge. So far it has not been possible to observe the number of moults which occur between larva and adult. In *Pediculopsis graminum*, the eggs are not deposited by the female mite but the young develop to maturity inside the body, which disintegrates to liberate numerous, fully-developed young.

Pediculopsis graminum is found not only on cereals and grasses but also on carnations, where it can introduce a fungus into the buds and produce a Bud Rot. In the United States, the fungus concerned is *Fusarium poae* (Peck) Wollenw. Work by Cooper (1940) has shown that although the mite can subsist on the *Fusarium* alone, its young forms, by their gnawing of the tender bud tissues, inoculate the bud with the fungus. If the species of *Pediculopsis* on corms is capable of migrating freely from *Botrytis*-damaged corms to healthy ones and then feeding on the healthy material, the spread of *Botrytis* among stored corms may result.

A series of preliminary experiments were made on the relationship between the mite and the fungus. Acidanthera corms, free from *Botrytis* and from mites, were placed on moistened filter paper in covered glass dishes 12 cm. in diameter. Great care was taken in the selection of the corms to ensure that no mites were present in small surface crevices. Each corm was numbered and observed daily over a period of eight weeks after an infested corm, or mites or eggs, had been introduced in the ways described below. The corms were kept at 20° C. A Berlese-Tullgren funnel was used to extract all the mites from the corms at the end of the period. Twenty-four corms, taken at random from the selected stock used for the experiments, were kept in glass dishes under the same conditions to act as controls, and these remained unchanged at the end of the eight weeks.

In the first experiment, which was made in duplicate, a corm with Botrytis Rot and heavily infested with the mites was placed among six of the *Botrytis*-free corms and at a distance of about 2 cm. from them, as shown in Plate IV, 1. Within 24 hours all the corms were heavily infested by mites, and large numbers remained on them for three weeks. After this time, however, the numbers decreased, and by the end of eight weeks no colonies had established themselves on the invaded corms. Only five mites were recovered from them, and the corms remained free from *Botrytis*. The experiment was repeated with the infested and infected corm surrounded by a ring of petroleum jelly which prevented the mites from migrating to the other corms, and these again remained free from infection.

In the second experiment six eggs taken from the midst of egg clusters on an infested corm were placed on each of nine, unwounded, healthy corms, and on nine healthy corms in which a small incision had been made at the apex. On all the corms the eggs hatched within a few days and larvae emerged, but after a week no mites were seen, and at the end of the eight weeks only one mite, an adult female, was recovered. Again the corms showed no sign of damage. In a similar experiment in which adult mites from an infested and infected corm were substituted for the eggs, the number of mites again decreased, and at the end of the eight weeks only four mites, all adults, were recovered. The corms remained undamaged and free from infection.

In the third experiment, six healthy corms were placed on a culture of *Botrytis gladiolorum* in a petri dish resting on moistened filter paper. Several adult mites were placed in the culture. After four weeks large colonies of mites had established themselves, but again at the end of the eight weeks the corms showed no signs of *Botrytis* infection or damage.

Finally mites were taken from a corm with Botrytis Rot and placed on slopes of potato dextrose agar. In four of the six tubes *Botrytis* developed and colonies of mites quickly established themselves. In this way, it was found possible to keep large numbers of the mites alive during the summer on cultures of *Botrytis gladiolorum* and *B. cinerea*.

The series of experiments indicated that the mite, *Pediculopsis* sp., is unable to establish itself in large, actively-reproducing colonies unless *Botrytis* is present, although they do distribute *Botrytis* spores. The experiments provided no evidence, however, that the mite is capable of spreading *Botrytis* infection by feeding on healthy corms.

Thanks are due to Dr. G. Owen Evans of the British Museum (N.H.) for his examination of the mites ; to Dr. J. A. Tomlinson for identification of the fungi and preparing the cultures ; and to Mr. W. F. Buck for the photographs.

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CONTROL OF CABBAGE ROOT FLY WITH BHC AND TAR OIL WASH

by B. D. MORETON AND W. I. ST. G. LIGHT

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To investigate possible alternatives to the use of calomel dust for the control of Cabbage Root fly (*Erioischia brassicae* Bouché) a trial was made at Higham, Kent, in 1950, with BHC (benzene hexachloride) and with tar oil winter wash. Primo cabbage was drilled in plots measuring 10 yards by 10 yards, each of which contained about 400 plants ; there were four replications of each treatment. The insecticides, at the dilutions given below, were applied to the soil at the base of each plant on May 2, as soon as the crop was singled—by which time egg-laying had already begun. Half of each of the BHC plots was treated again on May 23. The controls were not watered as the soil was moist. The results on June 29 were as follows :

Treatment (*one fl. oz. per plant*)	Hearting Cabbages per plot (*Mean for 4 plots*)
BHC (50 per cent wettable powder). 2 oz. in 5 gal. water*	373
BHC (50 per cent wettable powder). 1 oz. in 5 gal. water	369
Tar Oil Wash. 1 pint in 6½ gal. (0·5 per cent)	224
Control. Untreated	181

* Equivalent to 1/20 oz. of 2½ per cent BHC dust per plant.

There was no appreciable difference between the counts for the half plots treated once and treated twice with BHC, and the two halves of the plots appeared uniform in the field. The mean numbers of hearting cabbages are therefore given for the whole plots. Statistical examination of the results showed that the numbers with both of the BHC treatments were very significantly higher ($P = 0{\cdot}01$) than those with the tar oil wash and the controls ; and that those with the tar oil wash were significantly higher ($P = 0{\cdot}05$) than the controls.

The results were very striking in the field : all the BHC plots had a practically full stand, whereas in the untreated plots there was a loss of half the plants by Cabbage Root fly attack. Full records for yield were not obtained, but partial data indicated that the weight from the BHC plots was probably treble that from the untreated.

The tar oil wash gave a control that was statistically significant but commercially inadequate. With this treatment there was also some yellowing and a check followed by intensified Flea Beetle attack. Infestations of *Brevicoryne brassicae* were heavy in late June, and noticeably more severe on the tar oil wash and untreated plots than on those treated with BHC.

The crop outside the experimental area was treated by the grower, who applied BHC at the rate of 2 ounces of wettable powder in 5 gallons of water with a fruit-spraying machine having two lances with trigger releases. On each lance one nozzle was blocked and the other removed. By trial it was found possible to judge the trigger release necessary to give each plant roughly one fluid ounce. With one man on the tractor and two operating the lances, one and a half acres were treated in a day. A good control was obtained, in contrast with the 40 per cent loss frequently experienced on the farm.

The cost of the BHC treatment at the lower rate was approximately 4*s.* per acre for materials, as against nearly £4 for a single application of calomel dust.

LEAF BLOTCH OF COCKSFOOT

by HAROLD OWEN

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In the course of an investigation of leaf blotch disease of barley, the fungus that causes the disease (*Rhynchosporium secalis* (Oudem.) J. J. Davis) has also been isolated from rye and certain grasses, e.g., couch (*Agropyron repens*), soft brome (*Bromus mollis*) and wall barley (*Hordeum murinum*). While there are slight but fairly constant differences in shape of conidia and behaviour in culture between isolates from the several host plants, all appear to be referable to *R. secalis*.

Characteristic leaf blotch symptoms have been commonly seen on cocksfoot (*Dactylis glomerata*). In numerous collections on this grass from the Reading area, conidia have been invariably cylindrical, lacking the beak typical of *Rhynchosporium secalis*. In addition, growth in culture of isolates from *Dactylis glomerata* is quite different from that of isolates from other hosts. The mode of spore formation, on the host and in culture, is like that of isolates from other grasses bearing leaf blotch symptoms, and the character of the lesions is also similar.

The fungus causing leaf blotch disease of cocksfoot in North America was described by Caldwell (1937). He showed that it differed from the *Rhynchosporium* on other hosts by forming unbeaked conidia, and he named the species *R. orthosporum*. Until now this fungus has not been recorded from Britain, but the material described above appears to belong to *R. orthosporum*. The conidia agree sufficiently in their measurements, as shown by the following table:

	Length μ	Width μ
Caldwell	14·4–19·4	2·3–4·7 (50 spores)
Owen	14·5–21·0	2·5–4·8 (20 spores, in water)

Artificial inoculation tests have been successful in re-transmitting the fungus to cocksfoot, using inoculum from culture, but it was not transmitted to barley or *Hordeum murinum*.

Rhynchosporium orthosporum was also recently found on *Dactylis glomerata* from Norfolk ; I examined the specimen by courtesy of Dr. W. A. R. Dillon Weston.

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THE RED CORE DISEASE OF STRAWBERRY PLANTS ORDER, 1952

This new domestic Order, made by the Minister of Agriculture and Fisheries, came into operation on November 10th, 1952. Its main object is to prevent or hinder the further spread of Strawberry Red Core (*Phytophthora fragariae* Hickman). The presence of the disease is made notifiable and a ban is placed on the selling or planting (except on land already infected) of infected plants or plants which have been grown on infected land.

THE IDENTIFICATION OF APHIDS OF ECONOMIC IMPORTANCE

by H. L. G. STROYAN

Department of Zoology, University of Cambridge

The concluding part of this contribution is devoted to a key for the identification of apterous viviparous females of aphids belonging to those genera most likely to be encountered by economic entomologists in the course of their work. Again only generic characters are used, and the same initial warning must be given that the use of the key cannot be extended to the identification of general collections of aphids. Provided that this limitation is observed it is hoped that the key, combined with the foregoing generic descriptions†, will serve its purpose adequately. Plates II and III contain photographs of a few important species to assist rapid visual recognition.

KEY TO APTEROUS VIVIPAROUS FEMALES, OTHER THAN FUNDATRICES

Abbreviations : Roman numerals indicate joints of antennae.
Arabic numerals indicate segments of abdomen.

Siph. = siphunculi — P.t. = processus terminalis
Abd. = abdomen — Ant. = antennae

* indicates a genus described in preceding parts of this contribution.

1 (12) Siphunculi absent.

2 (3) With strongly developed segmental wax plates on the body (glandular areas with many irregularly arranged facet-like pores). On (1) *Populus nigra* and *italica*, in purse-shaped galls, (2) *Lactuca, Daucus, Rubus*, etc., on roots . . . . *PEMPHIGUS* Hartig.

3 (2) Without such segmental wax plates, or, if present, very small.

4 (11) Body more or less rounded, plump ; III, or occasionally II and III, longer than the remaining joints. Attended by ants, not very waxy.

5 (6) Second joint of hind tarsi very long, always more than half as long as hind tibia and often up to 2/3 as long. Large whitish to dirty yellowish aphids, with 6-jointed ant., living at roots of very many Compositae. Always attended by ants . . . . *TRAMA* von Heyden.

6 (5) Second joint of hind tarsi not abnormally lengthened ; small- to moderate-sized aphids on roots of grasses, etc., attended by ants. Ant. 5-jointed.

7 (8) II nearly as long as III, and of about the same thickness, so that at first sight the basal joint appears to be absent, the first joint seeming to be the second. Whitish to whitish-yellow, on roots of grasses, *Phaseolus*, etc. . . . . *TRIFIDAPHIS* Del Guercio.

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† Börner, in a recently published catalogue of the Aphids of Central Europe (*Mitt. Thüring. Botan. Ges.*, **4**, Beih. 3, 1952), has made many changes in both generic and specific names. As some of these changes may ultimately be accepted, it should be noted that the following names, throughout the present series of descriptions, have been used in the sense of Hille Ris Lambers (various published works 1938–48) rather than in that of Börner (1952) :

Acyrthosiphon Mordv. — *Sappaphis* Mats.
Aulacorthum Mordv. — *Appelia tragopogonis* (Kalt.)
Metopolophium Mordv. — *Brachycaudus prunicola* (Kalt.)
Rhopalosiphoninus Baker — *Sitobion avenae* (F.)

8 (7) II not abnormally elongate, shorter and distinctly thicker than III.

9 (10) Apical tergites of abd. emarginate, so that anus, cauda and anal plate come to lie dorsally. Primary rhinaria with a distinct fringe. On grass roots . . . *GEOICA* Hart.

10 (9) Apical segments of abd. with tergites normal, anus terminal and anal plate ventral. Primary rhinaria unfringed. On grass and sedge roots . . . *FORDA* von Heyden.

11 (4) Body spindle-shaped, with very small almost invisible wax plates whose diameter does not exceed the width of the femora. Ant. with apical joint the longest. In profuse, powdery, white wax meal on grass roots, not attended by ants . . . . *APLONEURA* Passerini.

12 (1) Siphunculi present.

13 (20) Siphunculi pore-like, not at all elevated above body surface.

14 (15) Siphunculi large, the horseshoe-shaped opercula conspicuous, surrounded by a few hairs forming an irregular ring. Living in (1) galls on *Ulmus* spp., (2) flocculent mealy masses on branches and roots of apple, or roots of pear, *Ribes* and *Senecio*. With more or less conspicuous wax plates consisting of rather large facets lying in circular or oval groups, often with one or two central facets . . . . *ERIOSOMA* Leach.

15 (14) Siphuncular pores smaller, horseshoe-shaped operculum not conspicuous, or if fairly conspicuous then body without wax plates.

16 (17) Body very elongate and flattened, whole dorsum fused into a strongly sclerotic carapace, adorned marginally with stiff spiny hairs. Ant. 4- or 5-jointed. Wax secretion and wax plates absent. On blades and in sheaths of grasses, not attended by ants . . . . *ATHEROIDES* Haliday.

17 (16) Body less elongate, but still flattened to some extent, dorsum membranous or partly spinulosely sclerotic, but not fused into a carapace. Ant. 6-jointed.

18 (19) Dorsum membranous, without spinules, but with few to many wax pores in groups segmentally, either forming pigmented wax plates or situated on spinal and marginal pigmented sclerites. Body less flattened. Marginal hairs simple, only one on each marginal sclerite or gland plate. Frons not acutely convex. In copious wooly wax on leaves of beech, particularly in ornamental hedges . . . . *PHYLLAPHIS* Koch.

19 (18) Dorsum adorned with segmental sclerotic spinulose areas, without wax plates or glandular pores. Body distinctly flattened. Marginal hairs on abd., where present, more or less modified, generally of a fan-like shape. Siphunculi larger, horseshoe-shaped opercula more conspicuous. Frons acutely convex. Rostrum exceedingly short and blunt. On Gramineae and Cyperaceae . . . . *SALTUSAPHIS* Theobald.

20 (13) Siphunculi always to some degree elevated, in shape cylindrical, conical, clavate, vasiform or, if almost flat, then on rather broad round sclerotic areas bearing hairs.

21 (34) Siph. on flattened sclerotic areas bearing rather numerous hairs, or on rather smaller hairy cones. Segmental wax plates absent. Tarsi always 2-jointed.

22 (23) Second joint of hind tarsi very long, as for section 5. On roots of Globe Artichoke, Thistle, *Artemisia* and *Ranunculus*. Attended by ants . . . . *PROTRAMA* Baker.

23 (22) Second joint of hind tarsi not abnormally elongated.

24 (25) Abd. with well-marked flat marginal tubercles present on 1–7, usually on distinct marginal sclerites. Rostrum with apical joint normal. Living on (1) *Cornus* spp., (2) roots of grasses or *Carex*, attended by ants . . . . *ANOECIA* Koch.

25 (24) Abd. without well-marked flat marginal tubercles situated on marginal sclerites (*N.B.* Do not mistake spiracular plates and stigmata for tubercles and marginal sclerites). Rostrum with apical joint either short, rather parallel-sided and blunt at the tip or long and dagger-shaped, with extreme apex acute and articulated as a separate joint. On various trees or shrubs, never *Cornus* or grasses.

26 (27) Apical joint of rostrum acute, dagger-shaped. On various genera of Coniferae . . . . *CINARA* Curtis, *s.l.*

27 (26) Apical joint of rostrum short and blunt.

28 (29) Abdomen with a large conical dorsal tubercle. On young branches of *Salix* spp. . . . . *TUBEROLACHNUS* Mordvilko.

29 (28) Abd. without a dorsal tubercle.

30 (33) Body nude.

31 (32) VI much shorter than V. Body hairs not arising from small scleroites. Siphuncular cones small and pale or larger and pigmented. On young branches of oak and beech, causing cambial hypertrophy and splitting of bark . . . . *LACHNUS* Burmeister.

32 (31) V & VI about equal. Body hairs arising from small dot-like scleroites. Siphuncular cones darkly pigmented. On stems of roses, usually near the ground and often covered by ants with earthen " runs " . . . . *MACULOLACHNUS* Gaumont.

33 (30) Body covered with a dense coat of flocculent wax. Siphuncular cones rather small, palish. On needles of *Pinus*, sitting in files. Not attended by ants . . . . *SCHIZOLACHNUS* Mordvilko.

34 (21) Siphuncular pores not on flattened hairy cones or hairy sclerotic areas.

35 (42) Siphunculi slightly elevated, rim-like structures, their height less than their diameter ; or if on small cones, then these are not adorned with hairs, the tarsi are 1-jointed and small wax plates are present on the body.

36 (37) Second joint of hind tarsi very elongate, as in section 5. Large aphids living on roots of liguliflorous Compositae, attended by ants . . . . *NEOTRAMA* Baker.

37 (36) Second joint of hind tarsi not thus elongated.

38 (39) Body with well-marked though small segmental wax plates, like those of *Eriosoma*. Tarsi 1-jointed. Body globular, with short appendages. Siph. rim-like, situated on small hairless flat cones. Pinkish aphids, on roots of grasses, with ants. Primary host elm, on which flask-shaped galls are caused on the leaf midribs . . . . *TETRANEURA* Hartig.

39 (38) Body without segmental wax plates. Tarsi 2-jointed.

40 (41) Body narrow and elongate, limbs long and agile. Ant. 6-jointed. Greenish to olive brown aphids, on needles of *Pinus* spp. . . . . *EULACHNUS* Del Guercio.

41 (40) Body normal but somewhat flattened. Ant. 5-jointed. Rather bristly, sometimes spinulose aphids, living on blades of grasses . . . . *SIPHA* Passerini.

42 (35) Siph. always at least somewhat elongate, longer than broad, cylindrical, tapering, clavate, vasiform or barrel-shaped.

43 (46) Abd. with a median backwardly directed process on the tergite preceding the cauda.

44 (45) Siph. longer than cauda, cylindrical or somewhat clavate. Nude aphids living on (1) leaves of *Salix* spp., (2) Umbelliferae of various genera, in flower heads, up stems and under leaves . . . . **CAVARIELLA* Del Guercio.

45 (44) Siph. shorter than cauda ; rather mealy aphids living on blades of grasses and cereals, which may be discoloured . . . . *CAVAHYALOPTERUS* Mimeur.

46 (43) Abd. without a median precaudal process.

47 (48) Compound eyes without any apparent posterior process or triommatidion (representing the larval eye). Small green to yellowish aphids living on *Chrysanthemum* and other Anthemideae (Compositae) . . . *COLORADOA* Wilson.

48 (47) Compound eyes with a clearly visible triommatidion delimited from the normal facets.

49 (52) Siphunculi moderately to strongly clavate or vasiform, 1½ or more times as wide at the broadest as at the narrowest point.

50 (51) Frontal region of head adorned with small scabrous spinules, or if these are not apparent, then abd. dorsum more or less sclerotic and pigmented. Apart from a constriction near the apex, the apical 2/3 of the siph. strongly and sharply swollen, the apical part before the flange with reticulate or reticulate-striate sculpturing. On bulbs, underground parts of potato plants, clamped mangolds, *Caltha*, creeping parts of nettles, *Oxalis*, etc., under stones or logs, and many other hosts . . . . **RHOPALOSIPHONINUS* Baker.

51 (50) Frontal region of head smooth. Dorsum of abd. not sclerotic and pigmented, or if pigmented sclerotic pattern present, then ant. III with rather numerous rhinaria not in a single row along joint. Living on (1) *Ribes* spp., (2) various Compositae such as *Sonchus*, *Lampsana*, *Picris*, and on *Rhinanthus* . . . . *HYPEROMYZUS* Börner.

52 (49) Siph. cylindrical, tapering or barrel-shaped, or if clavate then only slightly so, less than 1½ times as broad at widest as at narrowest part.

53 (66) Siph. with a well-marked and regular polygonally reticulate zone at apex.

54 (55) Siph. short, subcylindrical or subconical, sometimes irregularly swollen on one side, with a truncate or flared apex. Body clothed with long, acute or sometimes furcate, but never distinctly capitate hairs. On Betuleae, Salicineae or Sapindaceae (*Acer* and *Aesculus*), on leaves and fruits . . . . *CHAITOPHORUS* Koch, *s.l.* and *PERIPHYLLUS* Van der Hoeven.

55 (54) Siph. elongate, not subconical, often with a distinct apical flange. Body hairs, if simple and acute, not so long and prominent. Not on Betuleae, Salicineae or Sapindaceae, unless casually in the case of very polyphagous species.

56 (57) Siph. distinctly but slightly swollen on apical half. On Azaleas . . . . *MASONAPHIS* Hille Ris Lambers.

57 (56) Siph. cylindrical or nearly so, or with a slight taper from base to apex, occasionally with a mere trace of preapical swelling, not enough to be considered clavate.

58 (61) Dorsum more or less sclerotic, pigmented or unpigmented.

59 (60) Sclerotic dorsum colourless or nearly so, strongly pitted. Body and head adorned with longish, stout, capitate hairs. On *Corylus avellana* . . . . *CORYLOBIUM* Mordvilko.

60 (59) Sclerotic dorsum more or less brownish pigmented, or if not, at least not pitted. Body without capitate hairs. On (1) *Rubus* spp., (2) blades and inflorescences of grasses, sometimes *Carex*; one species on orchids in hothouses. Plate II, 2 . . . . **SITOBION* Mordvilko.

61 (58) Dorsum not sclerotic, if pigmented then only in small localized hair-bearing scleroites.

62 (63) Reticulate zone covering 2/5 or more of length of siph. Apical joint of rostrum acute, stiletto-shaped, with straight or even slightly concave sides. On *Chrysanthemum*, *Tanacetum*, *Artemisia*, *Achillea* and other Anthemideae . . . . *MACROSIPHONIELLA* Del Guercio.

(*N.B.* The subgenus *Asterobium* H.R.L. and *M. chamomillae* H.R.L. do not fit this diagnosis; but they are not likely to be met with in economic work.)

63 (62) Reticulate zone covering less, or not more, than 2/5 of the length of the siph. Apical joint of rostrum less acute, not stiletto-shaped, though sometimes long and thin.

64 (65) Dorsum with small segmental scleroites bearing the dorsal body hairs in most species. First tarsal joints with 5 hairs, or if not, then cauda black, or reticulate zone covering up to 2/5 length of siph. Bronze-brown to bronze-grey or garnet red to red-brown, living on stems, inflorescences or under basal leaves of Compositae and Campanulaceae . . . . *DACTYNOTUS* Rafinesque.

65 (64) Dorsum without spinal and pleural hair-bearing scleroites. First tarsal joints with 3 hairs. Cauda always pale. Green or reddish to deep violet red. On (1) Rosaceae, (2) Many hosts including Dipsacaceae, Umbelliferae, Valerianaceae, Ranunculaceae, etc. One species a pest on potatoes, tulips, etc. . . . . **MACROSIPHUM* Passerini.

66 (53) Siph. without a well-marked reticulate zone at apex.

67 (70) Body adorned with longitudinal rows of conspicuous capitate hairs. Whitish to pale green or straw-coloured to pinkish.

68 (69) Processus terminalis more than 5 times as long as base of VI. Siph. smooth, often slightly expanded or swollen towards apex. On (1) *Ribes* spp., (2) various Labiatae, including *Lamium*, *Stachys*, *Ballota* and *Galeopsis* . . . . **CRYPTOMYZUS* Oestlund.

69 (68) P.t. less than 5 times base of VI. Siph. imbricate, thin cylindrical or slightly tapering on basal 1/3. Body cuticle rugose, and head with spinulose papillae. On various Rosaceae, including strawberry . . . . *CHAETOSIPHON* Nevsky. **(PENTATRICHOPUS* Börner).

70 (67) Body not adorned with conspicuous capitate hairs.

71 (80) Cauda short, rounded, subpentagonal or triangular, with its length not or only slightly greater than its greatest width.

72 (73) Siph. with apex obliquely truncate, flangeless, with a small porus and distensible membranous operculum. Cauda a little longer than its greatest width, slightly constricted basally. Cuticle very strongly rugose, yellowish pigmented. Mainly on grasses at ground level, under stones, etc., but also casually on etiolated or senescent parts of other plants such as potato, *Lysimachia*, *Viola*, *Oxalis*. In damp shaded habitats . . . . *JACKSONIA* Theobald.

73 (72) Siph. with apex not obliquely truncate and with at least a small flange, operculum not distensible.

74 (75) Abd. without any trace of marginal tubercles. Siph. short, barrel- or flagon-shaped. Cauda triangular, length/basal width ratio about 10 : 9. Very waxy. In dense colonies up stems and under leaves of various Brassicae . . . . *BREVICORYNE* Van der Goot.

75 (74) Abd. with distinct marginal tubercles.

76 (77) Spinal tubercles absent, or present only on 8. Spiracles widely open, subcircular. On (1) *Prunus* spp., *Spiraea*, (2) various herbaceous plants, principally Compositae, but also Scrophulariaceae, Boraginaceae, *Trifolium*, *Rumex*, etc. Plate II, 1 . . . . **BRACHYCAUDUS* Van der Goot.

77 (76) Spinal tubercles present at least on head and 8; or if not, then abd. dorsum membranous, hardly pigmented, or siph. with closely set rows of blunt spinules. Spiracles not so widely open, oval or somewhat reniform.

78 (79) Siph. with closely set transverse rows of blunt spinules. Spinal tubercles present on all segments from head to 8, completely flat. Living (1) in longitudinally down-folded, rosy-discoloured leaves of pear, (2) on roots and basal collars of Umbelliferae. Attended by ants . . . . *ANURAPHIS* Del Guercio.

79 (78) Siph. with irregular imbrications, but not regular spinulose imbrications as above. Spinal tubercles on head (with rare exceptions, mainly on apple or *Plantago*) and variably on 6–8; sometimes also on a few other segments. Living (1) in twisted, crumpled or rolled, often yellow or red discoloured leaves of apple, pear, hawthorn or *Sorbus* spp., (2) basally on many species of herbaceous plants, especially Umbelliferae, but also *Rumex*, *Plantago*, *Galium*, *Arctium*, bulbs, etc. Attended by ants, except on *Plantago*. Plate II, 3 . . . . **SAPPAPHIS* Matsumura.

80 (69) Cauda elongate, always clearly longer than its greatest width, digitate, ensiform, tongue-shaped or triangular.

81 (84) Siph. very small and thin, less than half as long as the greatest width of cauda, and not more than half its length. Elongate aphids living on grasses, sometimes migrating from *Prunus*.

82 (83) Dorsal cuticle rugosely sculptured, and with up to about 4 rhinaria at base of III. Siph. with a very small apical flange. Pale yellow-green, not mealy. On *Dactylis glomerata* . . . . *HYALOPTEROIDES* Theobald.

83 (82) Dorsal cuticle not rugosely sculptured, without rhinaria on ant. III. Siph. flangeless, rounded at apex. Very mealy, pale green aphids living in colonies (1) on leaves of *Prunus*, (2) on various grasses and *Arundo* . . . . *HYALOPTERUS* Koch.

84 (81) Siphunculi not both very small and very thin ; if less than half width of cauda, then at least as long ; if less than half as long as cauda, then at least two-thirds as wide.

85 (86) Dorsal cuticle pale to yellowish sclerotic, with a well-marked variolar or pitted sculpture. Green, somewhat flattened. On leaves and shoots of *Rosa* spp. . . . . *MYZAPHIS* Van der Goot.

86 (85) Without strongly marked pitting of dorsal cuticle.

87 (92) Marginal tubercles always present, though sometimes very small, on 1 and 7, and frequently on other intervening segments. Lateral frontal tubercles small and low, not or only slightly higher than the median convexity of the frons.

88 (91) Marginal tubercles on 7 behind or dorsal to the spiracles of that segment.

89 (90) Abd. dorsum (on *Pyrus communis*) with a well-defined sclerotic pigmented area, and siph. shorter than cauda. Living (1) in contorted leaves of pear, (2) on blades of grasses (the latter form is very seldom encountered, is not economically important, and is not keyed in this couplet) . . . . *LONGIUNGUIS* Van der Goot.

90 (89) Abd. dorsum without a sclerotic and pigmented area, except for a small bar on 8. Siph. at least a little longer than cauda, and with a distinct apical flare of flange. Living on (1) *Prunus*, *Pyrus*, *Crataegus* and *Cydonia* spp., contorting leaves, (2) grasses and cereals . . . . **RHOPALOSIPHUM* Koch.

(*N.B. Schizaphis* Börner, on grasses and sedges, is rather similar, but the siph. is almost flangeless.)

91 (88) Marginal tubercles on 7 lying obliquely ventral to the spiracles. On very many plants, but not on grasses . . . . **APHIS* Linnaeus.

92 (87) If present, marginal tubercles do not occur on both 1 and 7. Lateral frontal tubercles variable, but usually rather pronounced, so that frontal outline is rather deeply concave or sinuate.

93 (94) Inner angle of lateral frontal prominence very strongly produced into an acute, elongate tooth-shaped process. Pale green aphids living (1) on *Prunus* spp., (2) under leaves and on stems and inflorescences of hops . . . . *PHORODON* Passerini.

94 (93) Inner angle of lateral frontal prominence much less or not at all produced, never forming an elongate forwardly projecting tooth.

95 (96) P.t. less than twice as long as base of VI. Frontal sinuation rather slight, lateral prominences not much developed. Small green aphids living on needles of spruce, sometimes causing scorching and defoliation . . . . *ELATOBIUM* Mordvilko.

96 (95) P.t. always appreciably more than twice base of VI. Frontal sinuation or concavity well-marked.

97 (102) Inner sides of lateral frontal prominences appreciably divergent from one another.

98 (99) Siph. slightly clavate. Living on *Rubus* or ferns . . . . *AMPHOROPHORA* Buckton.

(*N.B.* *Amphorophora gei* (Börner) on *Geum* spp. has the siph. more clavate, as for section 49 ; but is unlikely to be met with. It is entirely pale green with brown legs and ant., and has the siph. much more strongly flanged than in *Hyperomyzus*.)

99 (98) Siph. not at all clavate.

100 (101) Dorsum (except on *Ribes*) with a distinct pattern of darkly pigmented intersegmental sclerites, usually combined with a greater or less amount of dark suffusion of the central dorsum ; in some species the whole mid-dorsum including the intersegmental sclerites is blackish sclerotic. III with 4–35 tuberculate rhinaria. Spiracles widely open, subcircular. Living on (1) *Ribes* spp., (2) various Compositae, including *Lactuca*, *Crepis* and *Hieracium*, also sometimes *Veronica*. Plate II, 4 . . . . *NASONOVIA* Mordvilko.

101 (100) Dorsum without a distinct pattern, though the mid-dorsum may be indistinctly smoky in old specimens. III in normal apterae with only up to about 4 rhinaria at base, but in alatiforms with up to 20 or more along the whole joint, but not at all protuberant. Spiracles small, not widely subcircular. On Papilionaceae, Euphorbiaceae, *Lactuca serriola*, Malvaceae or Rosaceae, never on *Ribes*, nettles of grasses . . . . *ACYRTHOSIPHON* Mordvilko.

(*N.B.* Aphids on nettles which run down here belong in *Microlophium* Mordv., formerly treated by some authors as a subgenus of *Acyrthosiphon*.)

102 (97) Inner sides of frontal prominences either almost parallel or slightly produced inwards at apex, so that prominences do not appear divergent. (Caution : this character is often lost by flattening after mounting under a coverslip.)

103 (104) Frons with a distinct tubercle-like median prominence between the lateral ones, so that frons from above has a W-shaped outline. Living on (1) *Rosa* (1 species only), (2) various grasses. Plate III, 2 . . . . *METOPOLOPHIUM* Mordvilko.

104 (103) Frons without a distinct median prominence, though the outline may be convex between the bases of the lateral prominences. On many different hosts, but not on grasses.

105 (106) Abd. dorsum with a distinct and characteristic U-shaped pigmented sclerotic area, produced forward as broken lines of paired segmental sclerites. III scabrously imbricate on inner (anterior) side, and with 0–2 rhinaria at base. Head very spinulose. Inner sides of frontal prominences parallel. On many hosts, most numerous in glasshouses or indoors on pot plants, etc. . . . . *NEOMYZUS* Van der Goot. (subgenus of *Aulacorthum* Mordv.)

106 (105) Abd. dorsum, if pigmented, not with a distinct U-shaped central sclerite.

107 (108) III scabrously imbricate on inner side, always without rhinaria. Frontal prominences distinctly convergent ; dorsum rugose or wrinkled sclerotic, pale or variably pigmented. (These characters are not well developed in *M. ascalonicus* Doncaster, in which however the siph. are thin and definitely clavate.) Living on a great variety of hosts, with typical primary hosts among *Prunus* spp., association with which has been lost in various anholocyclic species. Plate III, 1 and 3 . . . . *MYZUS* Passerini.

108 (107) III not scabrously imbricate on inner side, usually with 1–3 rhinaria basally, at least on one antenna. Frontal prominences with inner sides parallel, not convergent. Dorsal cuticle variably sclerotic and pigmented, but not rugose. Siphunculi slightly tapering, with a distinct flange, never clavate. On a wide variety of hosts, no regular primary host association. Often overwintering viviparously in sheltered places. Plate III, 4 . . . *AULACORTHUM* Mordvilko, s.s.

INDICATIONS OF EFFECT OF YELLOW RUST ON YIELD OF WHEAT

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Yellow Rust (*Puccinia glumarum* (Schm.) Erikss. and Henn.) is the most important cereal rust in Britain. It is well recognized that in some seasons, and on the more susceptible varieties, it often causes a significant reduction in yield, but in the absence of controlled experiments, with plots kept free from rust by sulphur dusting or other means, there is little direct evidence as to the magnitude of the losses. Some valuable indications may, however, be obtained by comparing the yields from a susceptible and a resistant variety, at a number of centres, in years when rust was severe and when it was virtually absent. The purpose of this contribution is to provide an example of the use of this method, utilizing data obtained from some of the wheat variety trials conducted by the National Institute of Agricultural Botany in recent years.

In choosing the varieties for comparison in a first try-out of this method it had to be borne in mind that it is not necessarily the same variety which is most severely affected each season. Jubilegem was badly attacked in 1949 and 1950, while Nord Desprez suffered in 1951. Some varieties such as Wilma and Pilot, however, appear to be appreciably affected every year. Manners (1950) has shown that six physiologic races of the rust are common in Britain. Some are restricted to a few varieties ; others attack many. Races 6 and 8 are generally distributed and Jubilegem and Wilma are particularly susceptible to them. The same races occur on Juliana but it is fairly resistant. We have therefore chosen Wilma and Juliana as a pair of " susceptible " and " resistant " varieties for comparison.

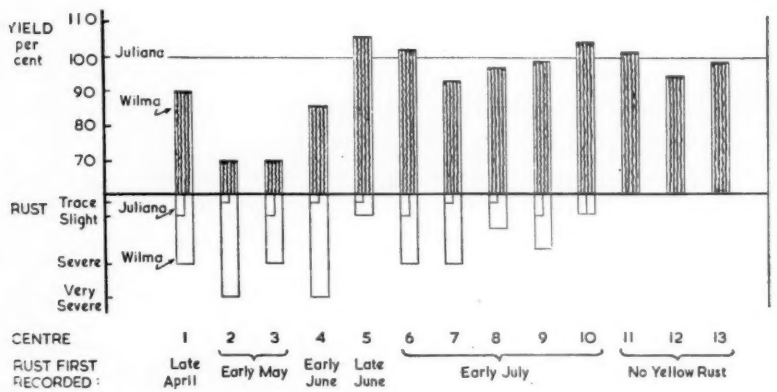

Fig. 1. Effect of time of appearance and severity of Yellow Rust on the yield of a susceptible variety of wheat at 13 centres in England, 1945 to 1947.

The yield of Wilma (highly susceptible) is expressed as a percentage of the yield of Juliana (fairly resistant).

Yellow Rust on Wheat

The results assembled in Fig. 1 show the yield of the susceptible variety as a percentage of that of the resistant variety in trials at 13 centres in England during the years 1945–47. Graphical indications of the severity of the rust on the two varieties at each centre, and the dates on which it was first recorded, are given for consideration with reference to the yields. The trial centres, with notes on the incidence and development of rust at each centre, are given below:

Centre	Incidence of Yellow Rust
1. Owstwick, Yorks, 1946	First seen April 17, severe by mid-June.
2. Cockle Park, Newcastle, 1946	Slight at beginning of May, developed rapidly, and severe by end of May.
3. Cannington, Somerset, 1946	Quite severe by end of May.
4. Harper Adams, Newport, 1945	Pronounced by June 3, severe by July 7.
5. Cambridge, 1945	Slight on June 25, very little increase.
6. Harper Adams, Newport, 1946	First seen July 2, fairly severe by July 16.
7. Sprowston, Norfolk, 1946	First seen July 11, then developed rapidly.
8. Cannington, Somerset, 1945	Not found June 11, slight to moderate on July 11.
9. Cambridge, 1946	Slight on July 8, fairly severe on July 19.
10. Harper Adams, Newport, 1947	Slight on July 4, little subsequent development.
11. Cambridge, 1947	No rust recorded.
12. Sparsholt, Hants, 1947	No rust recorded.
13. Sprowston, Norfolk, 1947	No rust recorded.

Fig. 1 indicates clearly that an early attack of Yellow Rust, i.e., up to about mid-June, may lower the yield of Wilma considerably. If rust attack is later than this, little reduction is to be expected. In five of the trials no rust was recorded or the attack was only slight, and the yield of Wilma was not significantly different from that of Juliana in any of these trials. The average yield of the two varieties was practically the same. Wilma, however, gave a significantly lower yield than Juliana in each of the four trials in which it was attacked by Yellow Rust before mid-June. In these trials the average yield of Wilma was only 78 per cent of that of Juliana.

Most of the severe attacks here discussed occurred in 1946. The rust was quite severe in that season, but it was not an exceptional year. In a season when rust is even more severe, greater yield reductions may be expected with susceptible varieties.

Reference

Manners, J. G. (1950). Studies on the Physiologic Specialisation of Yellow Rust (*Puccinia glumarum* (Schm.) Erikss. & Henn) in Great Britain. *Ann. appl. Biol.*, **37**, 187–214.

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THE GARDEN CHAFER ON GRASSLAND IN THE SOUTH-WEST

SURVEY AND CONTROL TRIALS, 1950 AND 1951

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The larvae of the Garden Chafer (*Phyllopertha horticola* L.) infest permanent grassland on chalk and limestone soils, and as a result of their feeding large patches of turf are damaged. The damage is aggravated by birds pulling out loose turf in their search for the grubs.

The adult beetles appear in May or early June, and the flight period lasts for three or four weeks. The eggs are laid in the soil near or on the emergence sites, and the grubs feed on grass roots. There are three larval instars, the third being reached in early autumn. The fully-fed larvae hibernate until the following spring when they pupate, emerging as adults a month later.

The pest is of economic importance in several parts of Dorset, notably in the areas about Litton Cheney and Little Bredy, the Sydling Valley and Frampton. It also occurs around Compton Abbas and Winterbourne Steepleton, and is very widespread and severe around Alton Pancras. Minchinhampton Common, in Gloucestershire, is heavily infested ; it has been found near Painswick, and there have been small isolated outbreaks on lawns about Bristol. In Somerset, heavily infested fields occur in the Swainswick, Cadbury Camp and Nailsea areas ; and it has been found at Barrow Gurney, Minehead, Exford and Chard. A heavy infestation was reported in Wiltshire, at South Cerney in 1949, and there are records of its occurrence near Salisbury, Trowbridge, Devizes, and Tidmouth. There is one record of an infestation near Dulverton in Devon.

SURVEY IN THE SYDLING VALLEY

In 1951, a survey was made on twenty-six farms, comprising an area of some 5,000 acres in the Sydling Valley and adjoining parts of the parish of Frampton, six to eleven miles north-west of Dorchester. The area included fields at a range of altitudes from the downland slope at 400–600 feet to the sides of the Sydling and Frome rivers at 250–300 feet. The survey area was bounded to the north by the Cerne Abbas–Maidon Newton road, beyond which the land was found to be free from chafer infestation. South of this line, 107 fields in all, selected at random, were examined by soil sampling for presence of the chafer larvae. Thirty-five of the fields were found to be infested, the rest free. No larvae were found in the twenty-three ley fields (of up to six years' standing) included in the survey ; but there were larvae in just over a third of the fields of permanent grass, and in about half of the rough grazings. It appeared that the pest had not spread from the rough grazings on the higher downland to the more fertile permanent grass and ley fields below. In some of the low-lying fields there were heavily infested patches, with no infestation in the downland above or in adjoining fields.

In the survey as a whole, most of the infestations were found on thin to medium chalk soils, and there were few on the medium or heavy loams. Half the permanent pastures mown for hay in 1950 were infested, but only one-quarter of those used for grazing. There was some indication that permanent pastures

used for grazing, which had received applications of phosphates and potash, were less heavily infested. Several farmers had rolled heavily infested patches of fields in an attempt to crush the larvae or to replant the grass pulled up by birds, but there was no evidence that this measure had any good effect. It was observed that 80 per cent of the permanent grass fields were ploughable, and infestations could be substantially reduced by ploughing-up and reseeding.

SPRAYING AND DUSTING TRIALS

In 1947 and 1948, in connection with his work on the ecology of the Garden Chafer, Raw (1951) carried out preliminary trials on the effect of dusting with 3·5 per cent benzene hexachloride at the beginning of the flight period to kill the adult beetles before egg-laying. The results were inconclusive, and it was clear that further trials were needed.

In June 1950, four plots in a permanent grass field at South Cerney, Wilts, having an estimated population of 350,000 chafers per acre, were sprayed in ideal weather with a benzene hexachloride wettable powder at 2½ lb. in 250 gallons of water per acre. Four alternating plots were left as unsprayed controls. The treatment did not prevent egg-laying.

In the same year dusting trials with a 3·5 per cent benzene hexachloride dust were also made. A heavily-infested permanent grass field on the eastern side of the Sydling Valley was chosen for this trial. The field was sampled on April 27, 1950, and the estimated chafer population was 672,000 per acre. There were three dusted plots with three alternating control plots, each 15 yards by 35 yards. The dust was applied on June 7, in ideal weather, at the rate of 70 lb. per acre, using a small, square-wheeled, dusting machine (Staniland and Mayor, 1948). The plots were sampled on August 15, taking twenty 2½-inch diameter cores from each. The total number of larvae found in the sixty cores from the dusted plots was 14 ; and 48 in the sixty cores from the untreated plots. The plots were again sampled in the same way on October 18 when the corresponding numbers of larvae were 16 from the dusted plots and 26 from the controls. There was little apparent injury to the turf on the dusted plots, but by October 18 the control plots were very severely damaged : the ground was spongy and the turf had been pulled up over the entire area by birds in their search for larvae. Possibly birds do not pull the turf when there is less than some certain concentration of larvae ; or it may be that benzene hexachloride taints the dusted area and renders it unattractive to birds. The trial indicated that such an application of benzene hexachloride dust may give a good control of the pest, provided that it is applied at the right time and in favourable weather. The female beetles emerge about a week after the males ; the best time to apply the dust is therefore about a week after the first beetles are seen.

Thanks are due to Mr. M. H. Davies for help with the field work ; to members of the Grassland Department, particularly Mr. T. W. Blood, who carried out the grassland survey ; and to Mr. A. L. Jackson, District Officer for the area, for help with the trial and survey arrangements.

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A NOTE ON BLACK LEG OF POTATO

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The etiology of Black Leg of potato has long been a subject of investigation. Burkholder and Smith (1949) described biochemical and biological methods whereby the causal organism could be distinguished from the other soft-rotting bacteria usually referred to in America as *Erwinia carotovora* (Jones) Holland. Using these methods, fifteen similar isolates were obtained at East Craigs, Edinburgh, in the summer of 1951, from three collections of potato stems and two of tubers; one typical isolate was confirmed by Professor Burkholder to react biochemically in the same manner as E.24 and E.65, two of his isolates which he classifies as *Erwinia atroseptica* (van Hall) Jennison. Hitherto, isolates from affected potatoes in this country have been ascribed to *Bacterium phytophthorum* (Appel) Stapp. While it has been shown that Black Leg in America and in Great Britain can be caused by the same organism, aspects of nomenclature are not discussed here, but the following notes on methods may be of interest.

Inability to utilize ethyl alcohol was found to be a reliable biochemical method of differentiating between the Black Leg organism and the other soft-rotting bacteria. For this purpose, Burkholder and Smith used 5 per cent ethyl alcohol in beef extract peptone broth with brom thymol blue as indicator. In the early stages of the work at East Craigs, infusion of horse heart was inadvertently substituted for meat extract and results were completely invalidated owing to the presence of fermentable sugars. Latterly, the alcohol medium has been prepared using 1 per cent peptone alone, distributed in measured quantities in the test tubes and autoclaved, filtered absolute ethyl alcohol being added aseptically so that each tube contained 5 per cent of alcohol, again using brom thymol blue as indicator.

The pathogenicity of these isolates from Black Leg plants was tested by wounding, at soil level, plants about 1½ or 2 feet high growing in a shaded glasshouse at about 15–16° C. The soil was drawn up to cover the wound but no bell jars were used. Under such conditions, the Black Leg organism alone brings about typical symptoms with rotting of the stems within seven days. Less virulent strains can, however, attack the succulent tissues near the top of the plants, especially when bell jars are used to maintain high humidity.

The Black Leg organism was easily isolated from infected tissue, stems or tubers, using the following screening tests: (1) a suspension was prepared by diffusing tissue in sterile water, (2) the suspension was streaked on meat infusion agar, (3) gram-negative colonies, non-fluorescent in ultra-violet light, were tested for ability to ferment salicin, (4) those which did ferment salicin were placed in the ethyl alcohol medium, (5) the pathogenicity of those which did not utilize ethyl alcohol was tested as described above.

The generous collaboration of Dr. W. J. Dowson, Cambridge University, and Dr. T. Gibson, Edinburgh and East of Scotland College of Agriculture, is gratefully acknowledged.

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DOWNY MILDEW OF ANTIRRHINUM IN ENGLAND AND WALES

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Peronospora antirrhini Schroet. has been known in Europe on the wild *Antirrhinum orontium* since 1874, but was not recorded on the cultivated *A. majus* until 1936, when it crippled about 50,000 seedlings at Carlow, Ireland (Murphy, 1937). As so frequently happens, this discovery soon led to others, and within the next ten years or so Downy Mildew was reported on the cultivated plant from U.S.A., Canada, Holland, Denmark, Sweden, Norway, Australia, and New Zealand.

In England it was first observed in 1937 on a nursery in Sussex (Green, 1938). All the seedlings on the nursery were destroyed and no antirrhinums were raised there the following spring, but despite these and other precautions the mildew was seen again in June 1938 in another nursery about three miles distant. On that occasion 21,000 seedlings in boxes were destroyed and those already planted out were pulled up and burnt (Moore, 1943). Isolated attacks occurred at Aberystwyth in 1940, in Surrey and Lancashire in 1947, while in April 1949 reports of the disease came in quick succession from several nurseries near the south coast. The attention of the provincial plant pathologists of the N.A.A.S. was then specially drawn to it and within two or three weeks details of 11 outbreaks had been received at the Plant Pathology Laboratory. They came mainly from the coastal counties of the south and south-west, but also from Herefordshire, Gloucestershire and North Wales. Growers co-operated willingly, and sometimes at considerable sacrifice, in an effort to eradicate the disease by destroying affected stocks, but already it was becoming obvious that the disease must have been present but unrecognized on cultivated varieties for a long time, both in this country and abroad.

During each of the three years 1950–52 the fungus has been recorded on about a dozen occasions, usually in April or May. No special survey of the disease has been made, but so far over fifty attacks have been recorded in twenty-five counties of England and Wales. About half of them have occurred in coastal counties and three-quarters in the southern half of the country, but the disease is evidently widely distributed throughout the country. In most of the outbreaks that have come to light, the fungus has had a very crippling effect on the young seedlings, which are normally raised under humid conditions. When the plants are raised under relatively dry conditions they suffer little damage, and commonly grow out of the disease, which then fails to attract attention.

Dark varieties appear to have been less severely affected than light ones, and, where successive sowings of the same seed were made, the early sowings frequently suffered more than the later ones. Some measure of control has been claimed with both copper and sulphur sprays, but reports on control measures have been conflicting and no proper trials have yet been made. There is some circumstantial evidence that *Peronospora antirrhini* is seed-borne, but proof is lacking. In 1949 surplus seed from a stock that had produced affected plants was tested at the Plant Pathology Laboratory. Some of the seed was germinated on a Copenhagen germinator, and from the remainder seedlings were raised in boxes of sterilized soil, but Downy Mildew did not develop. Similar negative results were obtained in 1952 by Mr. N. C. Preston, N.A.A.S., Wolverhampton. Yarwood (1947) also failed to find the fungus on or in the seed.

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LEATHERJACKETS, 1951–52

In the spring of 1951, Advisory Entomologists throughout England and Wales reported that leatherjackets (*Tipula* spp.) were causing more damage than usual on a wide range of crops. This had been forecast by Dr. M. Cohen from observations made in the previous year. The high spring population of leatherjackets was followed by a large emergence of crane flies during the late summer and early autumn. The reports for August, September and October showed that while crane flies were abnormally abundant throughout England and Wales, certain counties in the Northern, West Midland, South-Western and Welsh advisory provinces seemed to be the most seriously affected. Apart from the advisers' reports, there were many from the public, and the " plague " was referred to in the press and on the radio.

In November and December high leatherjacket populations were found in soil samples in Yorkshire and Lancashire, and in the West Midland and Northern provinces. All the available evidence then suggested that the pest would be troublesome in 1952, and in several provinces farmers were warned of this possibility. These fears were justified. Abnormally high populations continued to be found in grassland. Damage to winter wheat was reported in several provinces and it was unusually severe in the north. Damage to spring sown cereals was widespread in March, and in April the Advisory Entomologist for the West Midland Province reported that " the epidemic is the worst which can be remembered " and that " almost every ploughed-up old grass field and ley has been affected ".

In addition to the ubiquitous damage to cereals and other crops following grassland, there was a remarkable amount of damage on old arable land and to established grassland. Italian ryegrass was extensively damaged in Lindsey, and in Norfolk, in April, 100 acres of two-year-old, reseeded marsh had to be treated with bran and Paris green. On arable land, brassica crops, peas and beans, potatoes, lucerne, carrots, celery and lettuce were seriously damaged in several provinces, and loganberries and strawberries were damaged in the east and south-east.

Plant Pest Survey

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